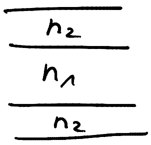
Dienstag, 21. Juni 2011
15:59

Rechenübung : F08

A6) 6.1.1.)



$$NA = \sqrt{n_1^2 - n_2^2} = 0{,}172$$

6.1.2.) a) $n_0 = 1 \qquad n_0 \cdot \sin\alpha_1 = NA \Rightarrow \alpha_1 = 9{,}9°$

b) $n_1 = 4 \qquad n_1 \cdot \sin\alpha_2 = NA \Rightarrow \alpha_2 = 2{,}46°$

6.1.3.) $\lambda \approx 1550\,nm \quad (1530 \dots 1580\,nm) \rightarrow$ geringe Dämpfung

6.2.1) $\alpha_{A_1} \cdot L \overset{!}{=} G_1$

$$L = \frac{G_1}{\alpha_{A_1}} = \frac{30\,dB}{0{,}25\,\frac{dB}{km}} = 120\,km$$

6.2.2.) $G_2 = \alpha_{A_2} \cdot L = 0{,}2\,\frac{dB}{km} \cdot 120\,km = 24\,dB$

6.2.3.) $\omega < 2{,}45$

$$\omega = k_0 \cdot a \cdot NA = 0{,}8 \cdot 2{,}405 = 1{,}924$$

$$a = \frac{1{,}924}{k_0 \cdot NA} = \frac{1{,}924}{\frac{2\pi}{\lambda_0} \cdot NA} = 2{,}33\,\mu m \qquad d = 2a = 4{,}66\,\mu m$$

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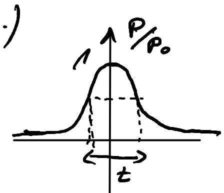
$$t_{opt1} = \sqrt{4L \cdot \frac{D_{A1}}{\omega c_0}} = \sqrt{4L \cdot \frac{D_{A1}}{2\pi c_0^2} \lambda_1} = 372{,}8\,ps$$

$$t_{opt2} = \sqrt{4L\,\frac{D_{A2}}{2\pi c_0^2}\,\lambda_2} = 229{,}4\,ps$$

6.2.5.)



$$E(\omega) = E_0 \sqrt{\frac{\pi}{2}}\, t_0 \cdot e^{\frac{-(\omega-\omega_T)^2 t_0^2}{8}}$$

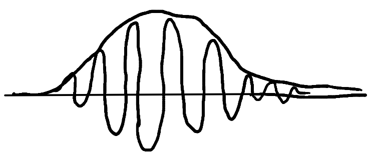
Abfall auf $\frac{1}{\sqrt{e}} \Rightarrow e^{\frac{-(\omega-\omega_T)^2 t_0^2}{8}} = e^{-1/2}$

$$E(t) = E_0 \cdot e^{j\omega_T t}\, e^{-2\left(\frac{t}{t_0}\right)^2}$$

$$\frac{(\omega-\omega_T)^2 t_0^2}{4} = 1 \qquad (f_{1,2} - f_T) = \pm \frac{1}{\pi t_0} \qquad \Delta f = |f_1 - f_2| = \frac{2}{\pi t_0}$$

$t_{opt1} \Rightarrow \Delta f_1 = 17\,GHz$

$t_{opt2} \Rightarrow \Delta f_2 = 2{,}775\,GHz$



6.3.1.) $t_{opt} = \sqrt{4L\,\frac{D}{\omega c_0}} = \sqrt{\frac{4}{2\pi c_0^2}\,L D \lambda}$

$(L \cdot D)_{gesamt} = L \cdot D_A + L_B \cdot D_B$ Damit bei beiden Wellenlängen das gleiche erreicht wird.

muss gelten: $(L D_{A1} + L_B D_{B1})\,\lambda_1 \overset{!}{=} (L D_{A2} + L_B D_{B2})\,\lambda_2 \Big\} \boxed{\Rightarrow L_B = 15\,km}$

$L \cdot D_{A1} = 15\,km \qquad L \cdot D_{A2} = 4{,}8\,km$

6.3.2.

$$\Delta f = \frac{2}{\pi t_0} \quad \text{mit} \quad t_0 = \sqrt{\frac{4}{2\pi c_0^2} L_i D_i \lambda_i} \qquad L_i D_i \lambda_i = L D_{A,1} \lambda_1 + L_B D_{B,1} \lambda_1 = 3{,}93 \cdot 10^{-3}$$

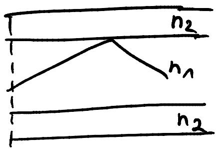
$$\Rightarrow t_{opt} = 166{,}73\,ps$$

$$\Delta f = \frac{2}{\pi t_0} = 3{,}82\,GHz$$

6.3.3) $g \leq L_B \alpha_B = 15\,km \cdot 0{,}4 \frac{dB}{km} = 6\,dB$

Aufg. 6 H2005)

6.1.1.)

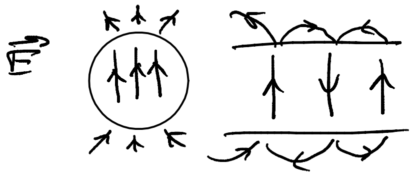


Ursache	Dominierend im Bereich
OH^- Absorption	$\lambda = 1380\,nm$
Rayleigh-Streuung	$\lambda \leq 1650\,nm$
IR-Absorption	$\lambda \geq 1650\,nm$

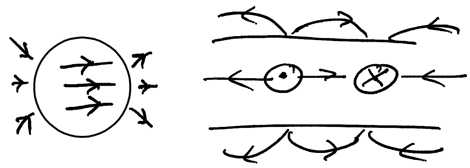
6.1.2)

LP_{01}

$\vec{E}$



$\vec{H}$ analog um 90° gedreht.



6.2.1)

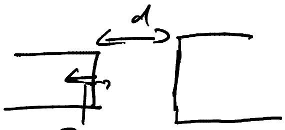
$$r = \frac{Z_0 - Z_{1A}}{Z_0 + Z_{1A}} = \frac{n_{1A} - 1}{n_{1A} + 1} = \frac{0{,}49}{2{,}49} = 0{,}1968$$

$$\frac{Z_0}{Z_{1A}} = \frac{\cancel{Z_0}}{\sqrt{\frac{1}{\varepsilon_A}} \cdot \cancel{Z_0}} = \sqrt{\varepsilon_A} = n_{1A}$$

6.2.2.) $N_{A_A} = \sqrt{n_{1A}^2 - n_{2A}^2} = 0{,}27$

$$n_{1B} = \sqrt{NA_B^2 + n_{2B}^2} = 1.53$$

6.2.3.)



$$Z_{1Bin} = \frac{Z_0^2}{Z_{1B}}$$

Extremfälle:

1.) $d = n \cdot \frac{\lambda_0}{2} \Rightarrow r_{A1} = \frac{n_{1A} - n_{1B}}{n_{1A} + n_{1B}} = -0{,}01324$

2.) $d = (2n-1)\frac{\lambda_0}{4}$ $\quad r_{A2} = \frac{Z_{1Bin} - Z_{1A}}{Z_{1Bin} + Z_{1A}} = \frac{n_{1A} \cdot n_{1B} - 1}{n_{1A} \cdot n_{1B} + 1}$

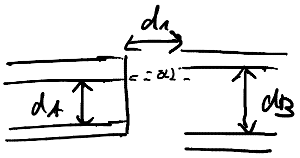
$$= 0{,}3902$$

$$P_{rmin} = P_{P\,EndeA} \cdot |r_{A1}|^2 \qquad P_{P\,EndeA} = P_P \big|_{dB} - \alpha_A L_A = -23 - 9 = -32 \big|_{dB}$$

$$= 6{,}3 \cdot 10^{-4} \big|_{W}$$

$$P_{rmax} = P_{P\,EndeA} \cdot |r_{A2}|^2 = 95{,}92\,\mu W$$

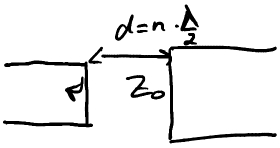
6.2.4.)



$$\tan\alpha = \frac{\frac{d_B - d_A}{2}}{d_1} \qquad \sin\alpha = N_A$$

$$d_1 = \frac{d_B - d_A}{2\tan\alpha} = \frac{d_B - d_A}{2\tan(\arcsin(NA_A))} = 85,15\mu m$$

6.3.1) für Abstand $d = n\frac{\lambda_0}{2}$ ist stets $P_r \le 1\mu W$



$$d = (2n-1)\cdot\frac{\lambda_0}{4} \quad P_r = P_{P\,Ende\,A}\left|\frac{\frac{Z_i^2}{Z_{1B}} - Z_{1A}}{\frac{Z_i^2}{Z_{1B}} + Z_{1A}}\right|^2 \le 1\mu W$$

$$\left|\frac{n_{1A}n_{1B} - n_i^2}{n_{1A}n_{1B} + n_i^2}\right| \le \frac{1\mu W}{6,3\cdot 10^{-4} W} = 1,58\cdot 10^{-3}$$

--> von 6.2.3

$$n_i^2 \ge \frac{1 - \sqrt{1,58\cdot 10^{-3}}}{1 + \sqrt{1,58\cdot 10^{-3}}}\cdot n_{1A}\cdot n_{1B}$$

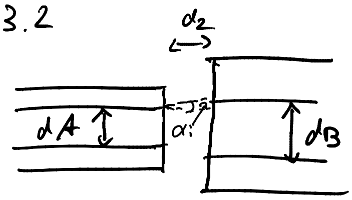
$$n_i \ge \sqrt{\frac{1 - \sqrt{1,58\cdot 10^{-3}}}{1 + \sqrt{1,58\cdot 10^{-3}}}}\sqrt{n_{1A}\cdot n_{1B}}$$

oder: $1,45 \le n_i$

$$n_i \le -\sqrt{\frac{1 - \sqrt{1,58\cdot 10^{-3}}}{1 + \sqrt{1,58\cdot 10^{-3}}}}\sqrt{n_{1A}\cdot n_{1B}}$$

$n_i \le -1,45$

6.3.2



$$\frac{d_B - d_A}{2d_2} = \tan\alpha_i \qquad n_i\cdot\sin\alpha_i = NA_A = 0,27$$

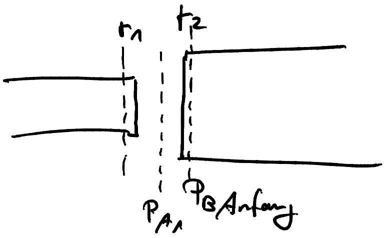
$$d_2 = \frac{d_B - d_A}{2\tan\left(\arcsin\left(\frac{0,27}{n_i}\right)\right)} \Longleftarrow$$

für $n_i = 1,45$

$132\mu m$

$d \ge 132\mu m$

6.3.3.



$$a = -10\log\left|\frac{P_{B\,Anfang}}{P_{A\,Ende}}\right| = -10\log\left((1-|r_1|^2)(1-|r_2|^2)\right)$$

$$P_{B\,Anfang} = P_{A1}(1-|r_2|^2) = P_{A\,Ende}(1-|r_1|^2)(1-|r_2|^2)$$

$$P_{A1} = P_{A\,Ende}(1-|r_1|^2)$$

$$|r_1| = \left|\frac{n_{1A} - n_i}{n_{1A} + n_i}\right| = 0,0133$$

$$|r_2| = \left|\frac{n_i - n_{1B}}{n_i + n_{1B}}\right| = 0,0265$$

6.3.4)

$$P_{B\,Ende} = P_A\cdot 10^{-\frac{\alpha_A L_A}{10}}\cdot 10^{-\frac{\alpha_B L_B}{10}}\cdot\underbrace{10^{-a}}_{=1} = 50\mu W$$